

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

- 1) A method of determining a treatment program for a subject, the method including:
 - a) Obtaining subject data, the subject data representing the subject's condition;
 - b) Using the subject data and a model of the condition to determine system values representing the condition;
 - c) Determining one or more trajectories representing the progression of the condition in accordance with the model and the determined system values; and,
 - d) Determining a treatment program in accordance with the determined trajectories.
- 2) A method according to claim 1, the subject data representing a medical condition for the respective individual, the method including determining trajectories representing the progression of the medical condition within the individual.
- 3) A method according to claim 1 or claim 2, each system value representing a quantity obtained for the measurement of a respective attribute of the condition, the system values including:
 - a) State variable values representing rapidly changing attributes; and
 - b) Parameter values representing slowly changing or constant attributes.
- 4) A method according to any one of the claims 1 to 3, the method including determining control variable values, the control variables representing attributes of the condition that can be externally controlled.
- 5) A method according to claim 4, the model including one or more model equations representing the condition, the method including determining one or more subject equations in accordance with the model equation(s) and the system values.
- 6) A method according to claim 5, the method of determining the treatment program including:
 - a) Evaluating the behaviour of trajectories representing solutions of the subject equations; and,
 - b) Determining one or more control programs, each control program including a sequence of control variable values that result in trajectories having desired behaviour.
- 7) A method according to claim 6, the method including determining a set of target points, the target points including stable points for the subject equation(s).
- 8) A method according to claim 7, the desired behaviour including at least one of:
 - a) The trajectories are acceptable;
 - b) The trajectories do not move away from the target points; and,
 - c) The trajectories finally approach the target points.
- 9) A method according to claim 8, the method including determining the solution trajectories to be acceptable if they are:
 - a) Non-chaotic; and,
 - b) Sufficiently smooth.

- 10) A method according to any one of the claims 7 to 9, the method of evaluating the behaviour of the trajectories including:
- a) Determining regions of control variable and/or parameter values for which the trajectories are chaotic; and,
 - 5 b) Determining ranges of the control variable and/or parameter values for which the trajectories can be made non-chaotic, or otherwise stabilised.
- 11) A method according to claim 10, the method including determining one or more control programs in accordance with the determined ranges.
- 12) A method according to any one of claim 10 or claim 11, the method including using a Liapunov
10 function to determine the one or more control programs.
- 13) A method according to claim 12, the method including:
- a) Defining a Liapunov function for which the gradient defines trajectories moving towards the target points;
 - b) Defining constraints on the control variable values; and,
 - 15 c) Determining control variable values that result in trajectories travelling down the gradient of the Liapunov function in accordance with the constraints.
- 14) A method according to claim 13, the constraints including limits on the treatment that can be provided to the subject.
- 15) A method according to any one of claims 10 to 14, the method including determining a treatment
20 in accordance with one or more of the determined control programs by:
- a) Viewing a representation of the trajectories, the representation including an indication of the chaotic regions; and,
 - b) Selecting a control program in accordance with the represented trajectories.
- 16) A method according to any one of the claims 6 to 15, the method including:
- 25 a) Determining one or more Nature values, the Nature values being quantities of Nature parameters and/or variables representing attributes of the condition that will cause the condition to progress in an undesirable manner; and,
 - b) Modifying the subject equations to incorporate the one or more Nature values;
 - c) Evaluating the behaviour of modified trajectories representing solutions of the modified
30 subject equations; and,
 - d) Performing at least one of:
 - i) Determining one or more control programs, each control program including control variable values that result in modified trajectories having desired behaviour; and,
 - 35 ii) Determining one or more undesired programs, each undesired program including Nature values that result in modified trajectories having undesired behaviour.

17) A method according to claim 16, the method including performing the method of any one of the claims 10 to 14 in accordance with the modified trajectories.

18) A method according to claim 16 or claim 17, the method including determining a set of undesired points, the undesired behaviour including at least one of:

- a) The modified trajectories are unacceptable;
- b) The modified trajectories do not move away from the undesired points; and,
- c) The modified trajectories finally approach the undesired points.

19) A method according to claim 17 or claim 18, the method including:

- a) Defining a second Liapunov function for which the gradient defines modified trajectories moving towards the undesired points;
- b) Defining constraints on the Nature values; and,
- c) Determining Nature values that result in modified trajectories travelling down the gradient of the second Liapunov function in accordance with the constraints.

20) A method according to claim 19, the method including determining the treatment program in accordance with control programs and the Nature programs by:

- a) Determining starting points having modified trajectories for which control programs exist;
- b) Determining starting points having modified trajectories for which Nature programs exist;
- c) Viewing a representation including at least one of:
 - i) The modified trajectories;
 - ii) The starting points; and,
 - iii) The chaotic regions; and,

d) Selecting a control program in accordance with one or more represented trajectories.

21) A method according to any one of claims 2 to 20, the method including determining parameter values by:

- a) Determining a partial set of system values from the subject data;
- b) Selecting one or more models, each model including a one or more equations representing the effect of a condition on an individual;
- c) Attempting to determine a complete set of system values in accordance with the determined partial set of system values and the respective equations; and,
- d) Selecting a model in accordance with the determined complete set of system values.

22) A method according to claim 21, the method of attempting to determine the complete values including:

- a) Determining a candidate set of system values in accordance with the determined partial set of system values and the equations; and,
- b) Comparing the candidate set of system values to at least one of:
 - i) The partial set of system values; and,

- ii) Predetermined thresholds; and,
 - c) Selecting the model in accordance with the result of the comparison.
- 23) A method according to any one of the claims 1 to 22, the method including:
- a) Determining stability sets; and,
 - 5 b) Determine the treatment in accordance with the stability sets.
- 24) A method according to claim 23, the stability sets representing combinations of state and parameter values for which the resulting trajectories are acceptable.
- 25) A method according to claim 23 or claim 24, the method including determining a control program in accordance with the stability sets.
- 10 26) A method according to claim 24 or claim 25, the method including:
- a) Considering subject state variable and parameters values for the subject;
 - b) Determining modification of the state variable and parameter values required such that the subject's state variable and parameter values fall within the stability sets; and,
 - c) Determining the treatment program in accordance with the required modification of the state
 - 15 variable and parameter values.
- 27) A method according to any one of the claims 22 to 26, the method including determining a medication dosage regime in accordance with the determined stability sets.
- 28) A method according to any one of the claims 1 to 27, the method including determining a control program using one or more of:
- 20 a) Liapunov functions;
 - b) Dynamic optimisation techniques;
 - c) Convex set algorithms.
- 29) A method according to any one of the claims 1 to 28, the subject being a patient.
- 30) A method according to any one of the claims 1 to 29, the treatment being the administration of
- 25 medication.
- 31) A method of determining a treatment program for a subject, the method being substantially as hereinbefore described.
- 32) Apparatus for determining a treatment program for a subject, the apparatus including a processing system adapted to:
- 30 a) Obtaining subject data, the subject data representing the condition;
 - b) Using the subject data and a model of the condition to determine system values representing the condition;
 - c) Determining one or more trajectories representing the progression of the condition in accordance with the model and the determined system values; and,
 - 35 d) Determining a treatment program in accordance with the determined trajectories.

- 33) Apparatus according to claim 32, the processing system being adapted to perform the method of any one of the claims 1 to 31.
- 34) Apparatus for determining a treatment program for a subject, the apparatus being substantially as hereinbefore described.
- 5 35) A computer program product for determining a treatment program for a subject, the computer program product including computer executable code which when executed on a suitable processing system causes the processing system to perform the method of any one of the claims 1 to 31.
- 10 36) A computer program product for determining a treatment program for a subject, the computer program product being substantially as hereinbefore described.
- 37) A method of determining system values representing a subject's condition, the method including:
- 15 a) Obtaining subject data, the subject data representing the condition;
- b) Determining a partial set of system values from the subject data, each system value representing a quantity obtained by the measurement of a respective attribute of the condition; *parameter values*
- 20 c) Selecting one or more models, each model including a one or more equations representing the effect of a condition on an individual;
- d) Attempting to determine a complete set of system values in accordance with the partial set of system values and the respective equations, for each model; and,
- 25 e) Selecting a model in accordance with the determined complete set of system values.
- 38) A method according to claim 37, the system values including:
- a) State variable values representing rapidly changing attributes; and
- b) Parameter values representing slowly changing or constant attributes.
- 39) A method according to claim 37 or claim 38, the method of attempting to determine the complete values including:
- 25 a) Determining a candidate set of system values in accordance with the determined partial set of system values and the equations; and,
- b) Comparing the candidate set of system values to at least one of:
- 30 i) The partial set of system values; and,
- ii) Predetermined thresholds; and,
- c) Selecting the model in accordance with the result of the comparison.
- 40) A method of determining system values representing a subject condition, the method being substantially as hereinbefore described.
- 41) Apparatus for determining system values representing a subject's condition, the apparatus including a processing system adapted to:
- 35 a) Obtaining subject data, the subject data representing the condition;

- b) Determining a partial set of system values from the subject data, each system value representing a quantity obtained by the measurement of a respective attribute of the condition;
 - c) Selecting one or more models, each model including a one or more equations representing the effect of a condition on an individual;
 - d) Attempting to determine a complete set of system values in accordance with the partial set of system values and the respective equations, for each model; and,
 - e) Selecting a model in accordance with the determined complete set of system values.
- 42) Apparatus according to claim 41, the apparatus being adapted to perform the method of any one of the claims 37 to 40.
- 43) Apparatus for determining subject parameters representing the effect of a subject's condition, the method being substantially as hereinbefore described.
- 44) A computer program product for determining system values representing a subject's condition, the computer program product including computer executable code which when executed on a suitable processing system causes the processing system to perform the method of any one of the claims 37 to 40.
- 45) A computer program product for determining subject parameters representing the effect of a subject's condition, the computer program product being substantially as hereinbefore described.
- 46) A method of determining the effectiveness of treatment provided to a subject, the method including:
- a) Obtaining subject data, the subject data representing the condition;
 - b) Using the subject data and a model of the condition to determine system values representing the effect of the condition;
 - c) Providing treatment to the subject;
 - d) Repeating steps (a) and (b) to determine modified system values;
 - e) Comparing the parameter values and the modified system values; and,
 - f) Determining the effect of the treatment in accordance with the results of the comparison.
- 47) A method according to claim 46, the method of determining the system values being a method according to any one of the claims 37 to 40.
- 48) A method of determining the effectiveness of treatment provided to a subject, the method being substantially as hereinbefore described.
- 49) Apparatus for determining the effectiveness of treatment provided to a subject, the apparatus including a processing system adapted to:
- a) Obtaining subject data, the subject data representing the condition;
 - b) Using the subject data and a model of the condition to determine system values representing the effect of the condition;

- c) Providing treatment to the subject;
- d) Repeating steps (a) and (b) to determine modified system values;
- e) Comparing the parameter values and the modified system values; and,
- f) Determining the effect of the treatment in accordance with the results of the comparison.

- 5 50) Apparatus according to claim 49, the processing system being adapted to perform the method of any one of the claims 46 to 48.
- 51) Apparatus for determining subject parameters representing the effect of a condition on a subject, apparatus being substantially as hereinbefore described.
- 10 52) A computer program product for determining the effectiveness of treatment provided to a subject, the computer program product including computer executable code which when executed on a suitable processing system causes the processing system to perform the method of any one of the claims 46 to 48.
- 53) A computer program product for determining the effectiveness of treatment provided to a subject, the computer program product being substantially as hereinbefore described.